Comparing socialization, cultural and individual level effects on attitudes towards nuclear energy - A multilevel analysis of 27 European countries

Jäckle, Sebastian; Bauschke, Rafael

Postprint / Postprint
Zeitschriftenartikel / journal article

Empfohlene Zitierung / Suggested Citation:
Jäckle, S., & Bauschke, R. (2011). Comparing socialization, cultural and individual level effects on attitudes towards nuclear energy - A multilevel analysis of 27 European countries. *PCS - Politics, Culture and Socialization*, *2*(4), 341-366. https://nbn-resolving.org/urn:nbn:de:0168-ssoar-71417-3

This is an accepted manuscript of an article published by Budrich Journals in Politics, Culture & Socialization, Vol. 2, No. 4, 2011, pp. 341-366 available online at:
https://www.budrich-journals.de/index.php/pcs/article/view/19748

Comparing socialization, cultural and individual level effects on attitudes towards nuclear energy – A multilevel analysis of 27 European countries

Sebastian Jäckle, University of Freiburg
Rafael Bauschke, University of Heidelberg

ABSTRACT

Despite visible cross-country variation in survey data on attitudes towards nuclear power in Europe, studies of nuclear risk perception have predominantly related peoples' attitudes to individual level factors. To account for the variance at the country-level, multilevel regression analysis, allowing for the integration of both individual and aggregate level factors, is proposed as a more fitting tool. Our model analyzes data from a 2008 Eurobarometer Special Issue on attitudes to nuclear energy. Apart from socio-demographic factors, geographic distance to the nearest nuclear power plant, knowledge concerning nuclear issues, trust in official sources as well as self-placement on a political scale show influences on attitudes towards nuclear energy at the individual level. At a country level, dependence on foreign energy sources and the electricity price do not prove significant, while socio-cultural factors, political socialization through Green parties and a familiarity effect are particularly important. The results suggest that the integration of aggregate level factors may help to develop a more complete understanding of public perceptions and of the effects of culture and socialization on attitudes.

KEYWORDS:
Nuclear energy – socialization - multi-level-analysis – Europe – risk perceptions

1. INTRODUCTION

The events at Fukushima Daichi in the wake of the devastating earthquake and tsunami in March 2011 reinforced worldwide debate on the use of nuclear energy. However, there are big differences in countries' reactions. While some of the strongest came from countries not yet using nuclear Energy (Israel and Venezuela, for example, decided to stop the development of the first nuclear power plants (NPP) in their respective countries), Germany clearly stands out when looking at those countries that already use nuclear power. The centre-right coalition government that had only in October 2010 enacted an extension of the operational life spans of German NPP for an average of 12 years, about-faced and decided immediately to shut down the seven oldest plants after the Fukushima incident and to proceed with an accelerated phase out of the remaining ones by 2022. In other countries, the renaissance of interest in nuclear energy that could be observed before the accident in Japan did not decrease as strongly: Most nuclear power countries only announced further security checks, some in addition temporarily froze their ongoing nuclear energy programs or authorization procedures (Switzerland, China, Taiwan), while others like France, the Netherlands and Turkey declared that they would continue with their plans for construction of new NPP.

These developments at the country-level are reflected by and are at the same time at least partially an implication of very diverse attitudes towards nuclear energy at the individual level. This paper focuses on these attitudes and analyzes which factors determine a positive or a negative stance by individuals in European countries towards atomic energy. Moreover, it is suggested that the cross-national variation is partially explained by effects of culture and socialization. Apart from questions concerning practical and technological implications as well as diplomatic and political consequences at the international level that a further expansion of nuclear energy would entail (Dhanapala, 2010; Diyakov, 2010; Goldschmidt, 2010; McCombie & Isaacs, 2010; Potter, 2010), the increased importance of the public in the implementation of all kinds of energy projects (Haggett, 2011; Valentine & Sovacool, 2010;

Wüstenhagen, Wolsink, & Bürer, 2007) underlines the relevance of taking into account peoples' perceptions when analyzing the future development of this source of energy. Democratic regimes depend on the goodwill of their citizens for the enforcement of large-scale energy projects and hence must respond to peoples' opinions on these issues. The major aim of this study is to test whether, apart from factors describing individuals, characteristics at a higher level of aggregation – in particular, at the country level – affect peoples' attitudes towards nuclear power.

The paper proceeds as follows. The second section surveys existing research on the topic from a number of different angles. This interdisciplinary view, taking into account perspectives from political science, sociology, psychology and geography, leads to the identification of several factors which potentially influence attitudes towards nuclear energy. The review of previous studies also reveals that perceptions of nuclear power and associated risks have primarily been related to personal characteristics and this individual level explanation has been the dominant perspective in most sociological and psychological studies (Sjöberg, 2000). Acknowledging the importance of individual characteristics – and thus controlling for factors found in present studies – we suggest that people's perceptions are also influenced by contextual variables which have to be measured at a higher level of aggregation. While individual factors explain the within-country variation, these level-2 factors account to a greater extent for the differences between the countries. Considering that current research on the perception of nuclear power does not adequately take into account these macro variables, political, economic and socio-cultural factors will be tested alongside energy-specific country characteristics such as the number of nuclear power plants operating in a country. With independent variables at the individual as well as at the country level, a multilevel analysis serves as the appropriate statistical approach.

The third section briefly describes the method inherent in this approach.

Section four presents the empirical analysis. In the first part of this section, we provide a descriptive cross-country overview of the two dependent variables measuring attitudes towards nuclear energy based on data from a Eurobarometer special issue from 2008 (Eurobarometer, 2008): First, the general **opinion** towards nuclear power and second, more specifically, the acceptance of three regularly made statements about the potential **benefits** of atomic energy. The second part of the section gives an overview of the operationalization and measurement of the independent variables. The statistical analysis follows in the remainder of this section. It builds on individual data from the Eurobarometer study and data measured at the country level. In contrast to previous studies, which focus mostly on local or single country analysis, the use of Eurobarometer data permits a more inclusive cross-country comparison that gives the results a higher degree of generalization. The paper concludes with a summary of the main results and some recommendations for a future research agenda.

2. EXISTING RESEARCH

2.1. Individual level (level-1)

Considering the research on attitudes and opinions from a psychological and sociological perspective, these criteria are to a large extent ascribed to characteristics of the individual. Studies have shown that socio-demographic characteristics such as gender, age and education have a strong influence on opinions in general. Particularly those attitudes connected with the values Ronald Inglehart associates with post modernity – among others, questions of economic and ecological sustainability – have been shown to be influenced strongly by these socio-demographic factors (de Groot & Steg, 2010; Franzen & Meyer, 2004; Inglehart, 2003; Inglehart & Baker, 2000; Torgler & García-Valiñas, 2007). Clearly, attitudes towards nuclear power – as one of the leading ecological and socially contested issues of contemporary society – should generally also be regarded as being influenced by such basic personal characteristics. Earlier studies have, indeed, identified effects for at least some of them: Men

mostly came out as being more in favor of nuclear power than women (Bassett, Jenkins-Smith, & Silva, 1996; Dunlap, Kraft, & Rosa, 1993; Eurobarometer, 2010; George & Southwell, 1986), while the impact of age has changed throughout the history of nuclear power. In the 1950s, younger respondents were more positive in their acceptance of atomic energy than older persons, but, from the 1970s onwards, this trend reversed and the youth became more hostile to nuclear power (Fisher, Metzner, & Darsky, 1951; Gamson & Modigliani, 1989). In trend terms, this is still the case, although more recent studies have found that differences between age groups have decreased or even vanished (Eurobarometer, 2007, 2010; Whitfield, Rosa, Dan, & Dietz, 2009). Descriptive statistics from the Eurobarometer series furthermore show minor differences between education levels (Eurobarometer, 2007, 2010).

A recent study conducted by Whitfield and his colleagues in the United States nevertheless did not find socio-demographic factors such as gender, age, education and income to be directly linked with the perception of nuclear power except for the fact that "nonwhites [were found to be] more supportive than whites". On the basis of a structural equation model, they argue that values and trust are the main driving forces of opinions on nuclear energy – both nevertheless depend heavily, although indirectly, on socio-demographic factors (Whitfield et al., 2009). In contrast to the Whitfield et al. study based on its own purpose designed survey instrument, we can only resort to data derived from the Eurobarometer questionnaire which does not allow to control for values. That being so, we do expect socio-demographic factors to show an impact. In contrast, the Eurobarometer data does allow testing for the relevance of trust. Trust has emerged within the last decades as one of the most important research interests in the functioning of "risk societies" (Beck, 2007). It is seen as a means of reducing the increasing complexity and uncertainty people are facing with the growth of technical intricacy (Giddens, 1990; Luhmann, 2000). Therefore, trust, for example in official

government agencies, should be of particular importance in an area as technologically complex as nuclear energy. Present studies confirm this (Slovic, Flynn, & Layman, 1991; Viklund, 2003; Whitfield et al., 2009). In conjunction with trust, knowledge is generally considered as a relevant factor in risk perception studies (Siegrist & Cvetkovich, 2000; Viklund, 2003) – for a more critical perspective compare (Sjöberg, 2001). A higher degree of knowledge is seen as enabling individuals to estimate risks in a more appropriate way leading to lower risk perceptions in general (Slovic, 1987) and, as Viklund highlights, for nuclear risks in particular (Viklund, 2003). Several studies have tested the relevance of further individual variables: number of children, income and political position (Benedict, Bone, Leavel, & Rice, 1980; Eurobarometer, 2007; George & Southwell, 1986; Whitfield et al., 2009). These will be used as controls in the following models.

Another level-1 factor that will be tested in this article is geographic distance to a nuclear power plant. The rationale behind the inclusion of this variable seems at first straightforward: Numerous studies have shown that perceived personal risk decreases with distance from the source of danger. This holds true for natural disasters such as hurricanes (Lindell, Lu, & Prater, 2005; Peacock, Brody, & Highfield, 2005), earthquakes or floods as well as for the man-made hazards constituted by technological facilities (Lindell & Hwang, 2008). With regard to this reasoning, we would expect greater distances to the next NPP to be correlated with lower risk perceptions translating into a more positive attitude towards nuclear energy. This would correspond to a 'not in my backyard' (NIMBY) mindset as studies have shown it for the new construction of NPP (George & Southwell, 1986). But this is only one side of the 'proximity-coin'. In contrast to the NIMBY syndrome, several studies have revealed that people are often less critical of nuclear power when they already live in the immediate vicinity of an operating NPP (Eiser, Pligt, & Spears, 1995; Greenberg, 2009; Melber, Nealey, Hammersla, & Rankin, 1977; Peters, 1980; Stagl, 1986; Venables, Pidgeon, Simmons, Henwood, & Parkhill, 2009). Possible explanations for this attitude include economic

dependence on the plant as an employer (Wynne, Waterton, & Grove-White, 2007) or some psychologically protective mechanism ("neighbourhood halo effect" (Bickerstaff & Walker, 2001)) helping to justify the choice of residence. All these explanations nevertheless focus on people living close to a NPP, whereas this is clearly not true for the majority of respondents in the Eurobarometer survey. Therefore any potential geographic effects will mainly rest on people living at a larger distance from a NPP. The theoretical argument is different for them: When the next NPP is very far away, perhaps even in another country, a "fear of the unknown", as it is known from psychological studies on diverse subjects, might be relevant and lead to a more negative attitude toward atomic power. Furthermore, as there are obvious age differences between NPP, which might in turn affect perceived safety, the age of the closest NPP is included as a control. Both directions of influence are plausible here: While the older a NPP, the higher is probably the risk associated with it but at the same time the customization of the public increases with its age which would foster a less negative attitude.

2.2. Aggregate level (level-2)

There are several potentially explanatory factors for personal perceptions that can be identified at the macrolevel. First, variance in attitudes toward nuclear power can be related to socio-cultural differences. With individuals being socialized in a specific context and with shared identities, beliefs and concepts providing a common framing of certain issues, a cultural influence on individual's perceptions can be hypothesized (Douglas, 1992; Douglas & Wildavsky, 1982). Its relevance for the analysis of risk perceptions has been highlighted in previous studies (Boholm, 2003; Gierlach, Belsher, & Beutler, 2010; Oltedal, Moen, Klempe, & Rundmo, 2004). While the concept of culture can refer to different levels, e.g. organizations or regions, the national level is generally believed to be one of the most relevant and, in a meta-study by Karahanna and her colleagues, has been shown to be widely used in

research (Hofstede, 1983; Karahanna, Evaristo, & Srite, 2005; van Everdingen & Waarts, 2003). We therefore use this level of aggregation as level-2 in the multilevel analysis.

In applying a political science perspective on individual perceptions, a second set of variables can be identified. A possible explanation for the cross-country variation could be the political socialization of the population (Poguntke, 2002; Rihoux & Rüdig, 2006). Considering the case of nuclear energy, the increased salience of environmental issues within the European Union and especially the nuclear question, traceable since the mid-1970s (Kitschelt, 1986; Surrey & Huggett, 1976), led to the establishment and rise of Green parties in at least some countries. If a Green party has strong representation in parliament or is even part of government, it will be able to establish debate about nuclear power high on the political agenda. Thus, there are two ways of influencing public opinion: Through parliamentary or governmental action. For both "Green variables" endogeneity could be a problem and should thus be acknowledged, as their causal relationship to the nuclear attitudes variables is somehow unclear. Green parties could also be strong (in parliament and government) because of a strong anti-nuclear position within the population. Probably both effects reinforce each other. We nevertheless assume the political socialization effect to be a relevant and probably even the more important one. A final test of the causality is nevertheless not possible without having panel data or doing process tracing in terms of more qualitative case studies. Another factor on which "political socialization" will depend is the provision of information via free media. According to Mazur "the mass media are the primary link between active participants in a (technocratic) controversy and the wider public. […] Thus information flows to the public through a narrow channel that is regulated by a small number of activists and media people" (Mazur, 1984). With studies proving that those elites who represent the broadcast and print media generally show a rather critical stance towards nuclear energy, especially when compared with scientific experts (Pollock, Lilie, & Vittes, 1993; Rothman & Lichter, 1987),

we assume that freedom of the press enhances the spread of a more critical perspective on the topic.

Furthermore, we suppose a more positive attitude towards nuclear energy in Eastern Europe. Two reasons can be mentioned here: 1) there has not been a similar long-lasting critical debate about atomic power specifically and energy issues in general within the Eastern European countries compared to that observable in Western Europe, and 2) during the EU accession negotiations, the Commission stipulated the shutdown of several reactors for security reasons as a prerequisite for accession (Bohunice in the Czech Republic, Ignalina in Lithuania, and Kozloduy in Bulgaria). The population in these countries as well as those in other countries dependent on electricity imports from these states reacted very negatively to these forced shutdowns.

A third group of contextual variables more specifically relating to the field of energy and nuclear politics must also be incorporated into the model. First, the number of NPP can be expected to influence individual perceptions, as a higher number of plants (in relation to a countries' population) should result in a higher level of familiarity with the issue and in perceiving nuclear power as something normal, more or less belonging to everyday life. Therefore, a familiarity and normality effect can be hypothesized: The more NPP are operating in a country per million of the population, the more positive the attitudes towards nuclear energy should be. Second, drawing on a rational choice perspective, factors connected with the consumption of energy are controlled for: On the one hand, the dependence on foreign energy imports, as a high dependence on foreign energy imports might stimulate public debates on the safeguarding of local energy supplies and therefore impact the acceptance of nuclear power as a possible way out of the energy dependency. On the other hand, the interaction between the electricity price and the share of atomic energy in a country is expected to have an impact. In cases when there is a high percentage of nuclear power and

at the same time the electricity price is high, or when both variables are low, we expect the people to hold a more negative stance towards nuclear energy.

3. METHOD: MULTILEVEL-ANALYSIS

While multilevel analysis has a long tradition in educational research (Burstein, 1980; Cronbach, 1976), this method has also proven to be suitable for the evaluation of risks as, for example, Poortinga has shown (Poortinga, 2005; Poortinga, Bronstering, & Lannon, Early View (Article first published online: 7 APR 2011); Poortinga, Cox, & Pidgeon, 2008). We, therefore, wish only to point out three main aspects that distinguish a multilevel model from a simple OLS regression and secondly focus on two methodological challenges that our specific research faces. For a general introduction to multilevel modelling see (Hox, 2010; T. A. Snijders & Bosker, 1999).

The three main differences to OLS are: First, multilevel analysis enables us to include variables measuring at a higher level of aggregation such as the ones described in the last section to account for a cross-country variation in the attitudes towards nuclear energy; second, the intercepts of the individual factors are allowed to vary randomly across countries (random intercept model) and, third, the slopes of the individual factors can also be modeled as randomly varying (random slope model). This technique allows for modeling the impact of covariates in such a way that their influence on the dependent variable can differ across the groups (countries) not only in terms of the level of impact, but also in terms of the causal direction of this impact. In cases when there is no significant variation between the slopes, the slope-parameters can also be fixed to obtain a parsimonious model which is still statistically adequate. This flexibility represents a big advantage of multilevel models over classic OLS-regressions, especially when a single explanation applying to all countries cannot be reasonably assumed. In this regard the multilevel model can be seen as an answer to critiques

raised from the perspective of qualitative research, asking for more context-specific explanations.

The first challenge in context of this study is the number of cases which is a crucial question for multilevel-analysis. As Snijders highlights, the overall number of level-1 units is relevant for testing level-1 effects (which should not be a problem in the present analysis with almost 26.000 individuals in the Eurobarometer sample), but if also level-2 variables are tested the "sample size at the highest level is the most limiting characteristic of the design", whereas the average group sizes are not very important for the power of the models (T. A. B. Snijders, 2005). Diverse rules of thumb for the minimum number of units are proposed – from approximately 30 to 100 (for an overview see (Braun, Seher, Tausendpfund, & Wolsing, 2010)). Although the 27 European countries we are able to use are definitely on the lower end of the 'rule of thumb scale', other studies have shown that, even with less level-2 cases, meaningful multilevel analyses can be conducted (Peffley & Rohrschneider, 2003; Rosar, 2003) and, in particular, that the restricted maximum likelihood (REML) estimation applied in the present analysis produces reasonable variance estimates even with very few level-2 groups (Browne & Draper, 2000; Maas & Hox, 2004). Nevertheless testing a higher number of level-2 variables might lead to a problem with the degrees of freedom (df). According to Hox with 24-30 groups the operating alpha-level, indicating the real amount of type I errors, is at about 9 per cent and thus higher than the nominal 5 per cent. This means that the estimated standard errors of the random variables probably have a small downward bias and therefore the significances of these estimates have to be interpreted somewhat more cautiously – the fixed parameters and their standard errors are accurate instead (Hox, 2010). For keeping the bias within reasonable limits, we have only estimated models with at least 15 degrees of freedom remaining for the residuals and to check the robustness of the results we applied a jackknifing procedure. Another necessity stemming from the small number of level-2 groups is to assume those slopes that are set to random to vary independently from each other.

The second challenge relates to the issue of centering. There has been a major debate in the literature whether and under which circumstances it is meaningful or even necessary to center the independent as well as the dependent variables before running a multilevel analysis, rather than simply using the raw scores. Two different ways of centering are proposed: Group mean and grand mean centering. Raudenbush recommends centering level-1 variables at their respective group means (Raudenbush, 1989). A routinely adoption of this kind of centering has been criticized for various reasons (Hox, 2010; Kreft, de Leeuw, & Aiken, 1995; N. T. Longford, 1989; N.T. Longford, 1989; Paccagnella, 2006; Plewis, 1989). All in all the advantages stated for group mean centering do not compensate for the problems it produces. Centering on the grand mean on the other hand does not have similar drawbacks. Models with grand mean centered independent variables are equivalent to models using raw scores, but the interpretation of the intercept and the level-2 intercept variance becomes meaningful in contrast to the raw score model where the value zero is perhaps not even possible (e.g. age). After centering the intercept can then be interpreted as the expected value of the dependent variable, when the independent variables take on their overall means (Hox, 2010). Hence the following analysis centers all independent level-1 variables on their grand mean except for dummies which all already have a meaningful zero.

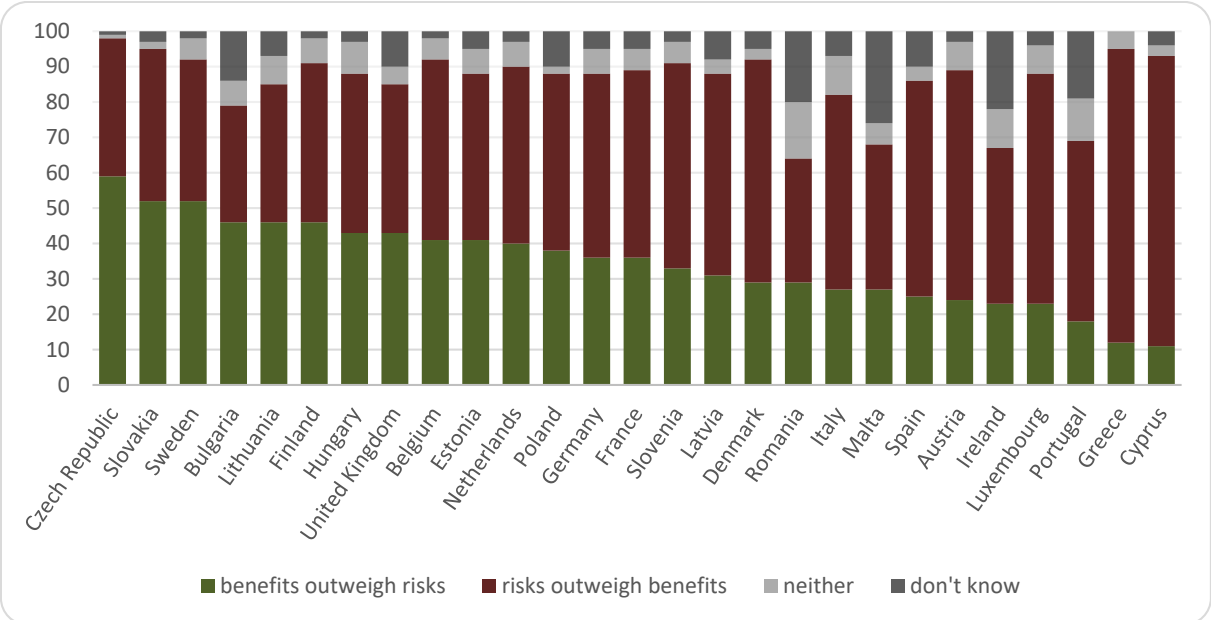
4. ANALYSIS

4.1. Measurement and description of the dependent variables: Large cross-country variations in attitudes towards nuclear energy

Several special issues of the Eurobarometer on nuclear energy in recent years have shown that questions on nuclear power generally manifest strong variation between the European countries. Graph 1 below depicts European perceptions about risks and benefits of atomic energy. We see that the vast majority of respondents have a clear stance towards nuclear energy – only in four countries (Romania, Malta, Ireland and Portugal), none of them

currently operating a NPP (Romania closed its last one in 2007) – are there more than one quarter of the people who see neither the risks outweighing the benefits or the other way round. Additionally, Europeans have very different perceptions when it comes to the risk-benefit ratio. Especially in the Central and Eastern European countries as well as in Sweden and Finland, we observe a higher percentage of people that regard the advantages of atomic power as more relevant than the risks. In Spain, Austria and especially in Greece and Cyprus on the other hand only a small minority thinks this way. The pattern found here in the 2010 special issue is also quite stable through time; there were only slight shifts compared to the previous Eurobarometer issue (Eurobarometer, 2007). Other questions on nuclear energy in general (e.g. on the security of nuclear waste management or the possibility of operating a NPP in a safe way) manifest a similarly large cross-country variation (Eurobarometer, 2007, 2008, 2010).

Graph 1. Perception of risks and benefits of nuclear power

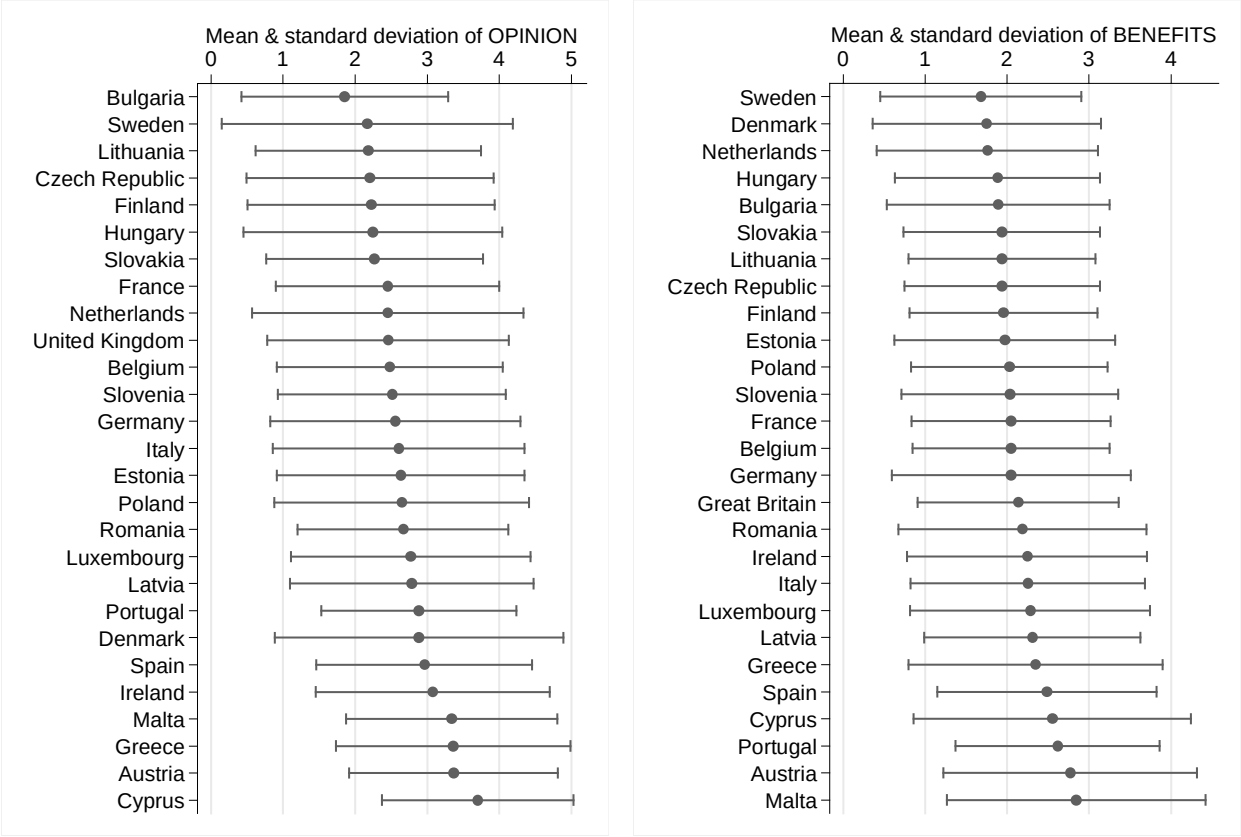


Source: Eurobarometer Special Issue 324, March 2010.

Drawing on these descriptives, it can be concluded that variation in the perception of nuclear power corresponds to a certain extent to differences between countries and therefore

potentially to effects of culture and socialization. To test this "socialization" claim, we consider two dependent variables, both stemming from a Eurobarometer special issue from 2008, measuring two interrelated but distinct aspects of attitudes towards nuclear energy (we resorted to the special issue from 2008, since the most recent Eurobarometer special issue on nuclear energy from 2010 lacks data on a number of independent variables). The first is the general opinion on nuclear energy (OPINION) operationalized by the question "Are you totally in favour, fairly in favour, fairly opposed or totally opposed to energy production by nuclear power stations?" The second variable tested is a simple composite index that depicts the overall approval of three statements often made about the benefits of nuclear energy (BENEFITS): 1) nuclear energy diversifies our energy sources, 2) nuclear energy reduces the dependence on oil and 3) nuclear energy reduces the emissions of greenhouse gases. The OPINION question as well as all three BENEFITS questions measure on a four-point scale. With the arithmetic mean being used for the aggregation, the whole BENEFITS index also ranges from one to four. Graph 2 gives a first descriptive overview of the two dependent variables. In both cases high values indicate a negative attitude towards nuclear energy. The correlation between the two variables is moderately strong ($r = .55$) which points to the fact that the acceptance of pro-nuclear statements is certainly connected to the overall opinion about nuclear energy, but further factors seem to be relevant for this more general attitude as well. Thus the BENEFITS-variable can be regarded as a specific sub-component of the OPINION-variable.

Graph 2: Means and standard deviations of the OPINION- and BENEFITS-variables



Source: Eurobarometer Special Issue 297, June 2008.

The considerable observed cross-country variation in average attitudes towards nuclear energy strongly suggests that individual perceptions may be subject to contextual factors at higher levels of aggregation and, most importantly here, at the national level. This calls for a more inclusive analysis beyond the individual level, testing for the relevance of the factors described in section 2.2. To test whether a multilevel analysis is really needed from a statistical point of view – i.e. to determine whether the variation across the level-2 groups is so big that it has to be explicitly accounted for – the intraclass correlation coefficient (ICC) can be calculated (Hox, 2010). The ICC is defined as the "between-groups effect divided by the total effect, for the null model" (Garson, 2010) specifying the percentage of the variance of the dependent variable that can be attributed to differences between the level-2 groups. With a resulting ICC of .209 for the OPINION variable and .158 for BENEFITS, about 21

(BENEFITS 16) per cent of the total variance can be attributed to differences between the nations, while about 79 (BENEFITS 84) per cent are due to within-group characteristics. Although the ICC shows that individual characteristics are probably the most important factors in explaining opinions on nuclear energy, there is a significant part of the variance which they cannot explain. According to Hox, the ICC levels observed here clearly necessitate multilevel analysis to examine existing variation in a statistically adequate way (Hox, 2010).

4.2. Measurement of independent variables

For most of the independent factors described in section 2, the operationalization and measurement are straightforward. Table A1 in the Appendix gives an overview of all variables, their coding, their construction and their sources. Some of them nevertheless deserve some short comments.

We used three dummy variables to determine, if a person lives in a rural area, in a small town or a large city. According to Inglehart the diffusion of post-materialist values is closely connected to urbanization which should foster a more critical stance towards nuclear energy in cities than in rural areas.

For testing the relevance of trust two operationalizations are used: First, the trust in official (pro nuclear) sources (government, national agencies, nuclear industry) which should have a positive influence on the attitudes toward atomic power and, second, the trust in more alternative sources of information (NGO, international organizations working on peaceful uses of nuclear power, media) which could be connected with a more negative stance towards nuclear energy. Knowledge is also measured in two different ways: First, real knowledge is measured by a cumulative index taking on higher values if respondents answer 12 knowledge based questions on nuclear issues asked in the Eurobarometer survey correctly and, second, the self-assessment of their knowledge on this topic. High real and self-perceived knowledge

should according to theory have a positive impact on the attitudes towards nuclear power. Cronbach's alpha for the knowledge index varies by country between 0.4 and 0.85 (mean = 0.6) indicating no perfect but at least a satisfactory internal consistency. The alphas for both trust indices are lower (varying by country between 0.15 and 0.65), nevertheless as Cronbach's Alpha heavily depends on the number of items (Carmines & Zeller, 1979) and both scales only consist of three items, these results can also be regarded as sufficient.

For testing the effect of having children the Eurobarometer question measuring the number of children until age 14 living in the household was recoded as a dummy variable. Counting only children until 14 could nevertheless be a too narrow operationalization for representing the family structure. Therefore, two further variables are tested: First, a simple dummy variable where the respondent lives singly, and, second, household size, which can be seen as a proxy for the number of children as well as for a more traditional family structure. The Eurobarometer does not ask for income. Hence, a prosperity index was constructed measuring the overall material well-being of respondents. Ideological position is measured via the respondent's political left-right self-placement.

The measurement of geographic distance to the next NPP proves to be more complex: As operationalization the distance 'as the crow flies' was chosen. Two approximations are necessary for the calculation: Since we do not know the respondent's exact place of residence, the center of the region where she lives (asked in the Eurobarometer) is used – thus geographic distance differs insofar from the other level-1 variables as it can only vary between regions, but not in between individuals from one region. The regions are in general based on the NUTS2 standard. The coordinates of the center of the region are derived from Google Maps and those of the NPP stem from the reactor database of the World Nuclear Association (http://world-nuclear.org/NuclearDatabase/Default.aspx?id=27232). For the actual calculation, we assume the earth to be a sphere which enables us to use the formula of the great circle to determine those distances.

For the characteristics of the 27 European countries - our level 2 factors - the following operationalizations were used. To measure the impact of national culture on individual perception, we decided to draw on the works of Geert Hofstede. He defines culture as "the collective programming of the mind which distinguishes the members of one group or category of people from another" (Hofstede, 1998), traceable in differing values, attitudes and beliefs. This definition allows for the inclusion of the national level as a unit of comparison since for some of these values "the nationality component is relatively strong" (Hofstede, 1998). Hofstede distinguishes five cultural dimensions: *Power Distance* measures the extent to which less powerful members of organizations and institutions accept and expect that power is distributed unequally. *Individualism* describes the extent to which people in a society are integrated into groups. *Masculinity* refers to the distribution of values between the genders. *Uncertainty Avoidance* indicates to what extent a culture programs its members to feel either uncomfortable or comfortable in unstructured situations. *Finally short-term vs. long-term orientation* distinguishes between societies fostering pragmatic virtues oriented towards future rewards versus virtues related to the past and present. It has been shown to be well suited for the comparison of the European countries from a cultural perspective (Kolman, Noorderhaven, & Hofstede, 2003). Data was obtained from Hofstede's website (http://www.geerthofstede.nl/research--vsm/dimension-data-matrix.aspx.).

We argue that varying acceptance of nuclear power can be partially attributed to different national cultures drawing on two of the five dimensions. First of all, *uncertainty avoidance*, can be expected to have an impact. Since the risks and benefits of nuclear power cannot be assessed precisely from the lay perspective, individual perceptions involve a certain level of uncertainty. The lower the societal tolerance for ambiguity and uncertainty, the higher the probability of a more reluctant position towards nuclear energy should be. Second, national differences in the *long-term* and *short-term orientation* of individuals can have an impact on

the perception of nuclear energy. As Hofstede suggests, short-term oriented societies tend to promote thinking in absolute terms, for example, the dichotomy of bad vs. evil, while long-term oriented societies foster the consideration of circumstances in such judgments. In addition, long-term orientation may result in a higher valuation of pragmatism.(Hofstede, Hofstede, & Minkov, 2010) In the context of nuclear power, we would expect long-term oriented societies to have a more positive perception of nuclear energy, based on a pragmatic as well as possibly more differentiated and not as a priori fixed perspective as short-term oriented societies exhibit.

For testing the impact of political socialization via Green parties and the media, three variables are used: One measuring the average seat share of Green parties in national parliaments between 1997 and 2007 (based on annual data), a second one measuring the percentage of time during the same period that a Green party was part of the government and the third variable measures the average freedom of the press between 1997 and 2007 using data from the freedom of the press index by Freedom House. We expect to find a more negative public perception in 'greener' countries and in those countries with a freer press.

The last variable that needs further explanation is the index combining the share of nuclear power (S) and the electricity price (P). This PS-index takes on high values either if there is a high percentage of nuclear power and the electricity price is high or if both variables are low. In both cases we expect people to hold a negative stance towards nuclear energy. Table I shows the constructional logic of the index:

Table I: The constructional logic of the PS-index and the expected influence on the opinions about nuclear energy

		electricity price (P)	
		low	high
share of nuclear energy (S)	low	anti (high PS-index)	pro (low PS-index)
	high	pro (low PS-index)	anti (high PS-index)

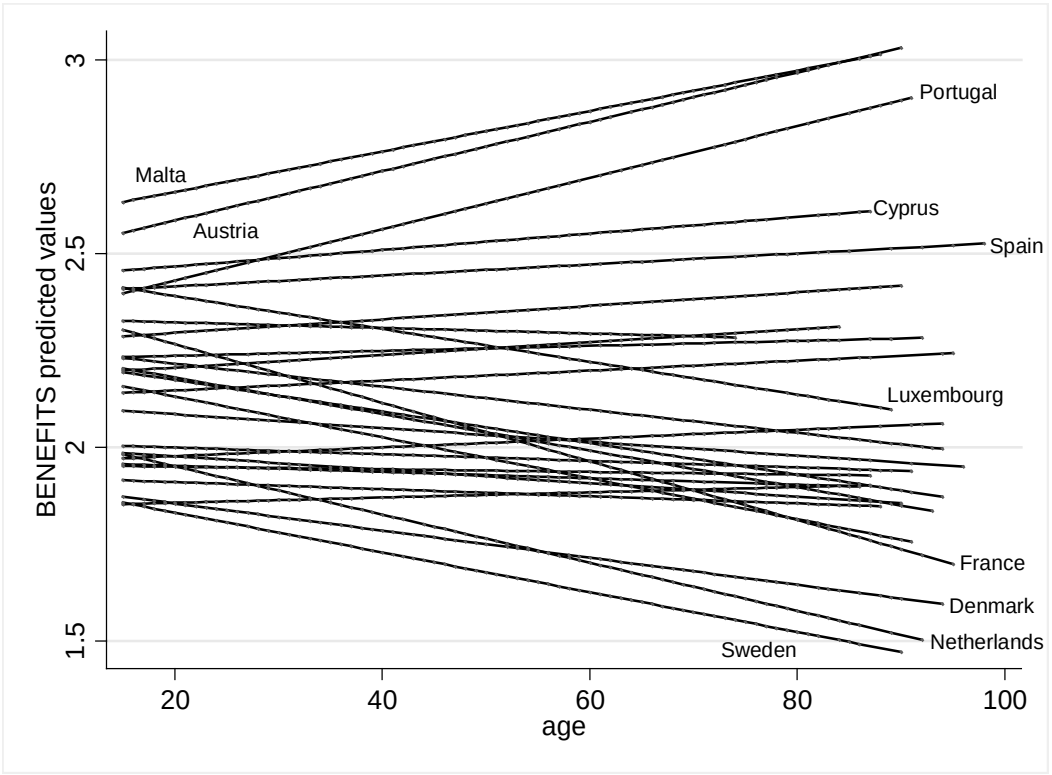
anti = negative attitude towards nuclear energy expected; pro = positive attitude towards nuclear energy expected. Explanatory note: For the calculation of the index: 1) the median of both variables (price and nuclear share) is subtracted from the empirical values, 2) the resulting values are standardized on an equal scale [-1, +1], 3) these rescaled values are multiplied and 4) the absolute values are taken and multiplied by 100 to achieve better interpretable coefficients.

4.3. Model building

The previous section showed how to measure the proposed explanatory factors. This section tests their influence on the two dependent variables OPINION and BENEFITS estimating multilevel regressions. Model building for both dependent variables followed four steps from which only the last ones are presented in table II (all models not presented here (also all jackknife models) are available from the authors). First an empty model was estimated (a model that only contains the dependent variable and the level-2 grouping variable, but no further independent variables); it is needed for the calculation of the ICC and as a reference for the more sophisticated models. In the second step, we estimated random intercept models including all individual factors suggested in chapter 2.1 as well as all level-2 variables described in section 2.2. The third step was to find a more parsimonious model. Therefore we dropped all the individual as well as aggregate variables that did not significantly improve the estimation. The final models presented in table II furthermore estimate random slopes for those level-1 variables where the slopes show significant variation across countries as indicated by a likelihood ratio chi square test (for a visualization compare Graph 3 which

illustrates the extremely diverse slope parameters for the variable ‘age’ in the BENEFITS model). According to Snijders and Bosker (1999), the amount of explained variation can be estimated separately for the two levels. Thus every model includes one R^2 for the micro-level (i.e. variation explained by individual characteristics) and one for the macro-level (i.e. variation explained by cultural and socialization effects on the country level).

Graph 3: Random slopes for ‘age’ in the BENEFITS-model



Based on BENEFITS-model with all significant level-2 variables and ‘age’ as the only independent level-1 variable.

Table II: Multilevel regression results for OPINION and BENEFITS

dependent variable	(model 1) OPINION		(model 2) BENEFITS		(model 3) OPINION	
Level-1						
Sex	-0.238***	(0.0283)	-0.167***	(0.0151)	-0.147***	(0.0219)
Age	-0.00168**	(0.000634)	-0.00191**	(0.000621)	-0.0000804	(0.000449)
Household size	0.00701	(0.00498)	0.0112***	(0.00340)	0.00576	(0.00442)
Single	-0.0405*	(0.0170)			-0.0115	(0.0151)
Age at end of education	-0.00925**	(0.00299)	-0.00386***	(0.00102)	-0.00403	(0.00221)
Prosperity index	-0.0156***	(0.00224)	-0.0142***	(0.00179)	-0.00784***	(0.00199)
Children dummy	0.0415*	(0.0171)			0.0225	(0.0151)
Self assessment nuclear knowledge	-0.147***	(0.00665)	-0.110***	(0.00540)	-0.0879***	(0.00596)
Knowledge nuclear energy	-0.0263***	(0.00449)	-0.0406***	(0.00521)	-0.00608	(0.00418)
Trust in official sources	-0.0809***	(0.0114)	-0.0655***	(0.00835)	-0.0433***	(0.00891)
Trust in alternative sources	0.0124*	(0.00624)	-0.0197*	(0.00862)	0.0246***	(0.00555)
Left-right selfplacement	-0.0275**	(0.00998)	-0.0147**	(0.00516)	-0.0190**	(0.00723)
Distance next NPP (log)	0.0372***	(0.00993)	-0.0145	(0.00796)	0.0451***	(0.00885)
Age next active NPP	0.00184*	(0.000768)			0.00170*	(0.000684)
Community size: rural (dummy)			0.0322**	(0.0108)		
Community size: small town (dummy)			0.0186	(0.0106)		
Benefits					0.557***	(0.0262)
Level-2						
Intercept level-2	0.0950***	(0.0286)	0.0402***	(0.0124)	0.209***	(0.0641)
Seat share Greens	0.0349	(0.0199)	0.0278*	(0.0131)	0.0177	(0.0298)
Long-term vs. short-term orientation	-0.00918*	(0.00391)	-0.00495	(0.00256)	-0.00892	(0.00585)
Reactors per population	-0.478**	(0.170)	-0.231*	(0.113)	-0.650*	(0.253)
Uncertainty avoidance			0.00325	(0.00170)		
Random effects						
σ_e^2 (level-1)	3.318***	(0.216)	2.211***	(0.191)	2.194***	(0.323)
T_{u0} (level-2)	0.627***	(0.00553)	0.414***	(0.00365)	0.495***	(0.00436)
T_{u1} (sex)	0.0187***	(0.00597)	0.00422***	(0.00168)	0.0105***	(0.00356)
T_{u2} (age)	0.00000692***	(0.00000258)	0.00000854***	(0.00000281)	0.00000236***	(0.00000117)
T_{u3} (age at end of education)	0.000180***	(0.0000640)			0.0000840***	(0.0000345)
T_{u4} (children dummy)	0.00177***	(0.00152)			0.00132***	(0.00114)
T_{u5} (knowledge nuclear)	0.000388***	(0.000146)	0.000629***	(0.000205)	0.000347***	(0.000128)
T_{u6} (trust official sources)	0.00230***	(0.000962)	0.00107***	(0.000510)	0.00118***	(0.000569)
T_{u7} (left-right selfplacement)	0.00249***	(0.000741)	0.000595***	(0.000198)	0.00126***	(0.000389)
T_{u8} (trust alternative sources)			0.00128***	(0.000560)		
T_{u9} (BENEFITS)					0.0171***	(0.00513)
N	25940		25940		25940	
df	17		17		18	
deviance	62049.93		51221.17		55951.56	
iterations	3		2		3	
R^2_{micro}	0.17		0.17		0.36	
R^2_{macro}	0.49		0.54		0.68	

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.4. Interpretation of the models

We first discuss the results based on the random slope model 1 in table II with OPINION as dependent variable. Variables like for example the community size dummies which did not show significant effects in the first-steps of the modeling process as well as those displaying certain collinearities, notably reducing the significance of the level-2 variables, were dropped.

The resulting, more parsimonious final models presented here show no relevant multicollinearity any more (highest VIF for all three models = 1.88). Hence and because of the significant reduction in the variance components that can be observed when compared to the empty models, they can be seen as the best fitting models for explaining the variance in attitudes towards nuclear energy. The coefficients are not standardized, thus they correspond to the effect on the dependent variable of a one point increase in the respective independent variable. Keeping in mind the coding and the 4-point scale of the dependent variable (high values indicating a negative attitude towards nuclear energy) the results for level-1 can be summarized as follows:

Men are more positive about nuclear energy than women. Under ceteris paribus conditions, men have an OPINION value that is 0.24 points lower than the one for women, which is more than 8 per cent of the whole scale. Additionally older people, singles, persons with a lower degree of education and people who are less wealthy as measured by the prosperity index are also more positive towards nuclear energy. In contrast, having children does not appear to have a similar strong impact, although this may well be a consequence of the operationalisation chosen, counting children only until the age of 14. However, the alternative operationalization in terms of household size that additionally can be seen as some proxy for a more traditional family structure shows no significant impact. When included without the other operationalization both variables (children dummy and household size) show a strong and significant effect.

As expected, perceived as well as the real knowledge of nuclear issues has a negative coefficient and thus a positive impact on the attitude towards nuclear power. These effects are also stronger than the socio-demographic ones: Someone who attests herself as having a very good knowledge has an OPINION score that is about 0.44 points lower than someone who describes herself as being not at all informed on nuclear energy issues. The effect of the real knowledge is a bit weaker: Those who answer all knowledge based questions correctly have

an OPINION score that is about 0.32 points lower than someone who has all answers wrong. As earlier studies have shown, trust also plays a relevant role: Those who say that they trust governments, national agencies and the nuclear industry have an OPINION score that is about 0.24 points lower than people who do not trust any of these actors. An opposite but much weaker and less significant effect can be found for trust in alternative sources. Political self-placement is another level-1 variable that shows a significant and relatively strong influence: Every point more towards the right on the 10-point left-right scale a respondent places herself means a reduction of about 0.03 points in the OPINION variable.

Geographic distance to the next active NPP is the last strongly significant effect at the individual level for the OPINION variable. As expected, an increase of this distance results in a more negative attitude towards nuclear energy; an effect that is not due to the probably very few Eurobarometer respondents living in the immediate vicinity of a NPP (for them an opposite effect could be expected according to the existing research), but to those living far away. This effect could be termed a 'fear of the unknown' as people in countries like Malta and Cyprus are not exposed to nuclear energy issues at all, which results in their very extreme positions. In accordance with the argument that it is more the large distance towards the next nuclear power plant that matters, the minor and only weakly significant effect of the age of the next NPP (as a proxy for it's perceived safety) becomes reasonable. The direction of the coefficient would speak for a higher risk perception of older NPP, but this effect is very weak – if the next active NPP is 40 years old this would only increase the OPINION score by 0.055 compared to the case that the next active plant is 10 years old. This effect should be stronger in an analysis that focuses on regions, where there are some NPP in the surrounding area, as for example the extensive protests from nearby German communities against the oldest French NPP at Fessenheim particularly show.

The R^2 for the micro level indicates that the individual factors tested in the model explain about 17 per cent of the variance in the OPINION variable located at the individual level. At

the macro level we find a higher explanatory power: 49 per cent of the level-2 variance can be explained by the country variables.

In concordance with the influence of political ideology on the individual level, we also expected a similar political socialization effect for the Green parties on level-2 and this expectation is, at least on the 0.1 level of significance, confirmed by the models. The average seat share of Green parties during the period 1997-2007 is a good explanatory factor for the level-2 variance. Given high multicollinearity between seatshare and government participation it is not possible to test both factors simultaneously. When government participation is controlled for without including seatshare, the effect is very much the same but slightly weaker than for seatshare. The interpretation of the level-2 coefficients is the same as for level-1: An increase of one percentage point for the seat share of Green parties within parliament means a plus of nearly 0.035 points on the OPINION score. Yet, as jackknife tests show, this effect is not as robust as others, leading to the conclusion that the effect of Green parties does not have the same relevance in all 27 European countries (while the Austrian Green party seems to make a difference, the Finnish Green party does not). Of course there are countries where no relevant Green parties exist, as in the case of Denmark. The Danish example points to a potential pitfall of the analysis with respect to Green parties. A Green and especially an anti-nuclear power agenda can also be pursued by parties not primarily coded as Green parties. The Danish social democrats and especially the far left *Enhedslisten* for example captured traditional green issues, resulting in the absence of a strong Green party in Denmark. In Germany in contrast, the cleavage between ecological and economic or industrial issues which emerged during the 1960s and 1970s was not internalized by the established parties, leading to the emergence of a strong Green party. Additionally, even among those parties coded as Green, we see a certain variation in attitudes towards nuclear energy. While the issue of nuclear power serves as the major point of identification for the Green party in Germany, in Latvia, for example, the Green party has its origins in the

agricultural milieu, where issues of nuclear power are far less important. These examples show that a more thorough inspection of the positions of all parties with regards to nuclear power is advisable when the effect of political socialization should be analyzed more precisely. All other variables – for OPINION as well as for BENEFITS – are robust in the jackknife models, indicating that the small number of level-2 groups does not pose a serious problem. Yet, the finding that political socialization can make a difference in the attitudes of the population is encouraging for Europe's Green parties as it stands in contrast to previous research that found only a weak societal impact of Green parties in government (Poguntke, 2002). In contrast, a political socialization effect via free press is not discernable. This result must nevertheless be qualified. As press freedom is heavily correlated with, among other things, the seat share of Green parties – which is why it is excluded from the final models – its genuine effect on attitudes to nuclear energy is hard to trace. When included without the multicollinear variables, its direction is as expected: People in countries that do not have free media are more positive towards nuclear energy, while press freedom seems to promote a more critical perspective on nuclear power.

When controlling for further factors, the dummy variable for Eastern European countries does not show a significant effect. Hence, and because other variables explain the differences between the countries in a more meaningful way than this simple dichotomy, the Eastern Europe dummy is not included in the final models.

Two of the factors potentially also explaining differences between Western Europe and the Eastern part of the continent are the socio-cultural variables *uncertainty avoidance* and *long-term vs. short-term orientation* derived from Hofstede. While uncertainty avoidance does not show a significant effect, long-term orientation does – although it is not very strong. The effect is in line with our expectations. People who live in societies that show a stronger long-term orientation hold a significantly more positive stance towards nuclear energy than those

with a short-term orientation. The assumption that a more pragmatic and less a priori fixed perspective on nuclear energy fosters a more positive perception thus seems to be valid.

The last group of level-2 variables tested shows diverse effects. While the number of NPP standardized on a country's population is highly significant – in countries where a high number of NPP are operating we find a positive attitude towards nuclear energy, indicating that people become familiar with this source of energy and its associated risks – the two remaining more rational choice variables, which control for dependence on external energy supply as well as the interaction between electricity price and nuclear share (PS-Index), show no large nor significant effects and are thus omitted from the final model.

Looking at model 2 with the second dependent variable, which depicts the overall approval of three statements often made about the benefits of nuclear energy, we observe some differences to the OPINION model, but in general the results are very similar. Also the R^2 for the micro and macro level do not change much. The BENEFITS variable can therefore be seen as a good cross-check for the first operationalization. Some of the discrepancies are nonetheless worthy of note: While no effects for the respondent's community size could be observed in the OPINION models, according to the BENEFITS model those living in rural areas are significantly more likely to agree with pro-nuclear statements than people living in larger towns. While this result could be plausible in light of the information/education divide between urban and rural areas, the negative coefficient for the 'trust in alternative sources' variable is puzzling, especially when compared with the OPINION model where we observed a significant positive coefficient. It means that people who trust the media, NGOs and international organizations working on peaceful uses of nuclear technology can identify themselves with pro-nuclear statements. One possible explanation is that particularly those people who do not trust anyone when it comes to nuclear power – and there are approximately 14 per cent in the sample after all – are those who are reluctant to agree with the BENEFITS

statements. This indicates that the 'alternative sources' are, at least in the view of many respondents, often not as alternative as we originally believed. The even more negative coefficient for 'trust in official sources' confirms this view. The other level-1 variables correspond largely with the OPINION model.

At level-2 we observe an influence of both Hofstede's socio-cultural factors, however only at the 0.1-level of significance. As hypothesized, people living in countries that have a weak tolerance for uncertainty disagree to a larger extent with the three pro-nuclear statements and the assumed effect of long-term vs. short-term orientation is affirmed as well.

The political socialization effect of Green parties in parliament and the familiarity and normality effect of the number of NPP operating in a country are both significant and as expected, although the latter is weaker than in the OPINION model.

A short excursion, taking the example of age in the BENEFITS model, will explain the interpretation of the random effects (for age: T_{u2}): For the average country we predict a decrease of 0.00191 in the BENEFITS score for every further year of the respondent's age. A 95 per cent confidence interval for the country slopes can be estimated as $0.00191 \pm 1.96\sqrt{0.0000854} = -0.00764\ to\ 0.00382$. Thus, assuming a normal distribution, we expect the middle 95% of countries to have a slope between these two values (Leckie, 2008). These results, showing that there are most likely positive and negative slopes for the variable age, confirm the picture in graph 3 which came to the same conclusion, although not controlling for the other individual variables. The graph already showed that while in some countries like Austria or Portugal becoming older is connected with a more negative attitude towards nuclear energy, in those countries where the population is in general more positive, the effect of aging is the other way round. This result could only be obtained due to the flexibility of the multilevel approach which allows testing different effects of covariates within different countries.

The third model in table II again explains the OPINION variable. It differs from model 1 only as it includes additionally the BENEFITS variable as an explanatory factor. As could be expected already from the significant bivariate correlation between OPINION and BENEFITS the latter shows a strong and significant effect on OPINION and accordingly the explanatory power of the model raises, while most other independent variables lose significance.

5. CONCLUSION

The major assumption of this paper is that beyond individual factors that have a long history in the field of attitude research, contextual factors – and effects of culture and socialization more specifically – measuring at a higher level of aggregation also play a role in determining attitudes towards nuclear power. This assumption is strongly supported by our analysis. Although the majority of the variance in the attitudes towards nuclear power (measured by the two dependent variables OPINION and BENEFITS from a 2008 Eurobarometer special issue) is contingent on individual factors, between 16 and 21 per cent of the overall variance is due to country differences. In contrast to existing studies, the multilevel regression analysis applied in this paper is first able to test individual as well as country-factors to account for both variances and second it also generates results that can be better generalized within the European context compared to existing studies mostly applying a single country design. Nevertheless it also has to be stressed that the correlations found in this analysis have to be interpreted with caution when it comes to causal explanations. We tried to make the possible underlying causality plausible, but further especially qualitative case studies are of avail to confirm our results. Six main results of this paper should be reemphasized.

First, the proposed model contributes significantly to the explanation of attitudes towards nuclear power within the European Union. Considering the respective R^2, it represents a well fitting model. Particularly the explained variance on level-2 between the countries ($R^2_{[macro]}$ =

0.52 for OPINION; and 0.56 for BENEFITS) is remarkable when compared with previous research that neglected the country level completely. Hence including country variables adds a significant proportion to the explanation of the attitudes towards nuclear power.

Second, beyond confirming the impact of most socio-demographic variables, the models especially indicate that a good real or self-perceived knowledge concerning nuclear issues as well as trust in the information given by official sources significantly increases the positive perception of nuclear energy.

Third, the use of geographic data, more specifically, the distance between the respondent's region and the next active NPP, resulted in the identification of a 'fear of the unknown' effect: The larger the distance, the more critical the attitude towards nuclear energy. Although having the same consequences, this anti-nuclear effect should be viewed separately from those pro-nuclear effects that have been previously shown for people living in the vicinity of a NPP. Our analysis suggests that two different causal logics are at work here: one fostering pro nuclear attitudes in the immediate vicinity of a NPP through economic dependence, customization or a psychological halo effect and the other one fostering anti-nuclear attitudes in those areas where people are not at all exposed to nuclear energy and thus exhibit a "fear of the unknown". However, given the proxy character of how the distance measure was calculated, further research on the question of spatial influence on perceptions is clearly required.

Fourth, the strength of Green parties showed significant impact. In countries where a Green party is strong within the national parliament, people are much more critical of nuclear power than in countries where Green parties are not relevant within the party system. This suggests that political socialization via agenda setting by Green parties through parliamentary (or governmental) action is possible and that it influences people's attitudes, although as jackknife test show, this effect differs widely among countries. While political socialisation has not been considered extensively in previous studies on (risk) perceptions, our results

relativize findings from political science studies which show only a weak influence of green parties in power on policies. However, especially here we must acknowledge the potential problem of endogeneity calling for a cautious interpretation of the results.

Fifth, while those level-2 variables associated with a more rational-choice perspective (dependence on foreign energy imports, interaction between electricity price and the nuclear share) do not show significant effects, the positive impact of the number of NPP operating in a country indicates a familiarity or normality effect.

Sixth, we found some influence of socio-cultural factors. In societies that have a high tolerance for uncertainty respondents at least in the BENEFITS model were more positive towards nuclear power. Furthermore people living in societies with a strong long-term orientation are more positive than those from short-term oriented countries. This is probably due to the more pragmatic and less a priori fixed perspective they employ on nuclear energy. That result could also be an explanation for the changes in attitudes toward nuclear power which were detected by surveys conducted after the Fukushima disaster (IPSOS, 2011; Jones, 2011). Particularly in long-term oriented societies these shifts would be expected. This finding may lend support to the necessity to include cultural aspects in the study of risk – an issue that has been considered extensively between proponents of cultural theory and the psychometric approach.

Apart from the specific results regarding attitudes towards nuclear power, a more general recommendation arises from this work. The proposed multilevel methodology in combination with cross-national survey data (e.g. Eurobarometer, World Value Survey) has proven to be suited for this research topic as it explains parts of the variance that were previously neglected and as it generates more robust as well as results better generalizable to the population under research than single case/country studies. Moreover, classical psychological survey studies which certainly have some advantages over a secondary data analysis like the one conducted in this paper – especially when it comes to the identification of the impact of individual

characteristics – could merit from an inclusion of macro level factors. Yet the theoretical and methodological approach taken here is not only appropriate for analyzing perceptions of nuclear power, but seems equally applicable to other kinds of perceptions of risk. Hence taking level-2 variables like cultural framings or political socialization (they do not necessarily have to be located on the country-level) seriously could help painting a more complete picture of the underlying dynamics determining peoples' perceptions of diverse risks.

References

Bassett, G. W., Jenkins-Smith, H. C., & Silva, C. (1996). On-Site Storage of High Level Nuclear Waste: Attitudes and Perceptions of Local Residents. *Risk Analysis, 16*(3), 309-319.

Beck, U. (2007). *Weltrisikogesellschaft - auf der Suche nach der verlorenen Sicherheit*. Frankfurt am Main: Suhrkamp.

Benedict, R., Bone, H., Leavel, W., & Rice, R. (1980). The Voters and Attitudes toward Nuclear Power: A Comparative Study of "Nuclear Moratorium" Initiatives. *The Western Political Quarterly, 33*(1), 7-23.

Bickerstaff, K., & Walker, G. (2001). Public understandings of air pollution: the 'localisation' of environmental risk. *Global Environmental Change, 11*(2), 133-145.

Boholm, Å. (2003). The cultural nature of risk: Can there be an anthropology of uncertainty? *Ethnos: Journal of Anthropology, 68*(2), 159 - 178.

Braun, D., Seher, N., Tausendpfund, M., & Wolsing, A. (2010). Einstellungen gegenüber Immigranten und die Zusatimmung zur Europäischen Integration - eine Mehrebenenanalyse, *Working Paper* (Vol. 136). Mannheim: Mannheimer Zentrum für Europäische Sozialforschung.

Browne, W. J., & Draper, D. (2000). Implementation and Performance Issues in the Bayesian and Likelihood Fitting of Multilevel Models. *Computational Statistics, 15*(3), 391-420.

Burstein, L. (1980). The Analysis of Multilevel Data in Educational Research and Evaluation. *Review of Research in Education, 8*, 158-233.

Cronbach, L. J. (1976). *Research on Classrooms and Schools: Formulation of Questions, Design, and Analysis*. Stanford: Stanford University.

de Groot, J. I. M., & Steg, L. (2010). Relationships between value orientations, self-determined motivational types and pro-environmental behavioural intentions. *Journal of Environmental Psychology, 30*(4), 368-378.

Dhanapala, J. (2010). The management of npt diplomacy. *Daedalus, 139*(1), 57-67.

Diyakov, A. S. (2010). The nuclear "renaissance" & preventing the spread of enrichment & reprocessing technologies: a Russian view. *Daedalus, 139*(1), 117-125.

Douglas, M. (1992). *Risk and blame: essays in cultural theory*. London/New York: Routledge.

Douglas, M., & Wildavsky, A. B. (1982). *Risk and culture: an essay on the selection of technical and environmental dangers*. Berkeley: University of California Press.

Dunlap, R. E., Kraft, M. E., & Rosa, E. A. (Eds.). (1993). *Public Reactions to Nuclear Waste - Citinzens' Views of Repository Siting*. Durham: Duke University Press.

Eiser, J. R., Pligt, J. v. d., & Spears, R. (1995). *Nuclear neighbourhoods - community responses to reactor siting* (1. publ. ed.). Exeter, Devon: Univ. of Exeter Press.

Eurobarometer. (2007). *Special Issue: Europeans and Nuclear Safety* Brussels: European Commission.

Eurobarometer. (2008). *Attitudes Towards Radioactive Waste*. Brussels: Eurpoean Commission.

Eurobarometer. (2010). *Special Issue: Europeans and Nuclear Safety*. Brussels: European Commission.

Fisher, B. R., Metzner, C. A., & Darsky, B. J. (1951). *Public Response to Peacetime Uses of Atomic Energy*. Ann Arbor: University of Michigan - Survey Research Center.

Franzen, A., & Meyer, R. (2004). Climate Change in Environmental Attitudes? An Analysis of the ISSP 2000. *Zeitschrift für Soziologie, 33*(2), 119–137.

Gamson, W. A., & Modigliani, A. (1989). Media Discourse and Public Opinion on Nuclear Power: A Constructionist Approach. *The American Journal of Sociology, 95*(1), 1-37.

Garson, D. (2010). Linear Mixed Models, from Statnotes: Topics in Multivariate Analysis. Retrieved 25.12.2010, from http://faculty.chass.ncsu.edu/garson/PA765/multilevel.htm#rcneeded

George, D. L., & Southwell, P. L. (1986). Opinion on the Diablo Canyon Nuclear Power Plant: The Effects of Situation and Socialization. *Social Science Quarterly, 67*(4), 722-735.

Giddens, A. (1990). *The consequences of modernity*. Cambridge: Polity.

Gierlach, E., Belsher, B. E., & Beutler, L. E. (2010). Cross-Cultural Differences in Risk Perceptions of Disasters. *Risk Analysis, 30*(10), 1539-1549.

Goldschmidt, P. (2010). Multilateral nuclear fuel supply guarantees & spent fuel management: what are the priorities? *Daedalus, 139*(1), 7-19.

Greenberg, M. (2009). Energy sources, public policy, and public preferences: Analysis of US national and site-specific data. *Energy Policy, 37*(8), 3242-3249.
Haggett, C. (2011). Understanding public responses to offshore wind power. *Energy Policy, 39*(2), 503-510.
Hofstede, G. (1983). The Cultural Relativity of Organizational Practices and Theories. *Journal of International Business Studies, 14*(2), 75-89.
Hofstede, G. (1998). A Case for Comparing Apples with Oranges. *International Journal of Comparative Sociology, 39*, 16-31.
Hofstede, G., Hofstede, G. J., & Minkov, M. (2010). *Cultures and Organizations: Software of the Mind* (3 ed.). New York: McGraw-Hill.
Hox, J. J. (2010). *Multilevel analysis - techniques and applications*. New York, NY u.a.: Routledge.
Inglehart, R. (2003). *Human values and social change*. Leiden u.a.: Brill.
Inglehart, R., & Baker, W. E. (2000). Modernization, Cultural Change, and the Persistence of Traditional Values. *American Sociological Review, 65*(1), 19-51.
IPSOS. (2011). Die meisten Atomkraftgegner in Deutschland, Italien und Mexiko - Weltweite Ipsos-Studie belegt: Fukushima hat in vielen Ländern zu Umdenken geführt Retrieved 22.06.2011, from http://knowledgecenter.ipsos.de/downloads/KnowledgeCenter/67F6B1C4-CC4A-4636-A948-1860CB7A00B1/PI-Atomkraft_Juni2011.pdf
Jones, J. M. (2011). *Disaster in Japan Raises Nuclear Concerns in U.S.* Princeton: Gallup.
Karahanna, E., Evaristo, J., & Srite, M. (2005). Levels of Culture and Individual Behavior: An Investigative Perspective. *Journal of Global Information Management, 13*(2), 1-20.
Kitschelt, H. P. (1986). Political Opportunity Structures and Political Protest: Anti-Nuclear Movements in Four Democracies. *British Journal of Political Science, 16*(1), 57-85.
Kolman, L. K., Noorderhaven, N. G., & Hofstede, G. (2003). Cross-cultural differences in Central Europe. . *Journal of Managerial Psychology, 18*(1), 76-88.
Kreft, I. G. G., de Leeuw, J., & Aiken, L. S. (1995). The Effect of Different Forms of Centering in Hierarchical Linear Models. *Multivariate Behavioral Research, 30*(1), 1.
Leckie, G. (2008). Module 5: Introduction to Multilevel Modelling - Stata Practical. Retrieved 03.01.2011, from http://www.cmm.bris.ac.uk/lemma/file.php/13/module05p/5-stata.pdf
Lindell, M. K., & Hwang, S. N. (2008). Households' Perceived Personal Risk and Responses in a Multihazard Environment. *Risk Analysis, 28*(2), 539-556.
Lindell, M. K., Lu, J.-C., & Prater, C. S. (2005). Household Decision Making and Evacuation in Response to Hurricane Lili. *Natural Hazards Review, 6*(4), 171-179.
Longford, N. T. (1989). Contextual Effects and Group Means. *Multilevel Modelling Newsletter, 1*(3).
Longford, N. T. (1989). To center or not to center. *Multilevel Modelling Newsletter, 1*(3), 7-11.
Luhmann, N. (2000). *Vertrauen - ein Mechanismus der Reduktion sozialer Komplexität*. Stuttgart: Lucius und Lucius.
Maas, C. J. M., & Hox, J. J. (2004). Robustness issues in multilevel regression analysis. *Statistica Neerlandica, 58*(2), 127-137.
Mazur, A. (1984). Media Influences on Public Attitudes Toward Nuclear Power. In W. R. Freudenberg & E. A. Rosa (Eds.), *Public Reactions to Nuclear Power: Are There Critical Masses?* (pp. 97-114). Boulder Colorado: Westview.
McCombie, C., & Isaacs, T. (2010). The key role of the back-end in the nuclear fuel cycle. *Daedalus, 139*(1), 32-43.
Melber, B., Nealey, S., Hammersla, J., & Rankin, W. (1977). *Nuclear Power and the Public: Analysis of Collected Survey Research*. Seattle: Human Affairs Research Center.
Oltedal, S., Moen, B.-E., Klempe, H., & Rundmo, T. (2004). Explaining risk perception: An evaluation of cultural theory. Trondheim: Norwegian University of Science and Technology.
Paccagnella, O. (2006). Centering or Not Centering in Multilevel Models? The Role of the Group Mean and the Assessment of Group Effects. *Evaluation Review, 30*(1), 66-85.
Peacock, W. G., Brody, S. D., & Highfield, W. (2005). Hurricane risk perceptions among Florida's single family homeowners. *Landscape and Urban Planning, 73*(2-3), 120-135.
Peffley, M., & Rohrschneider, R. (2003). Democratization and Political Tolerance in Seventeen Countries: A Multi-level Model of Democratic Learning. *Political Research Quarterly, 56*(3), 243-257.

Peters, W. (1980). Das Kernkraftwerk Biblis - Räumliche Distanz als Parameter der Meinungsbildung. *Geographische Rundschau, 32*(2), 71-77.
Plewis, I. (1989). Comment on "Centering" Predictors in Multilevel Analysis: Choices and Consequences. *Multilevel Modelling Newsletter, 1*(2), 10-12.
Poguntke, T. (2002). Green Parties in National Governments: From Protest to Acquiescence? *Environmental Politics, 11*(1), 133-145.
Pollock, P. H., III, Lilie, S. A., & Vittes, M. E. (1993). Hard Issues, Core Values and Vertical Constraint: The Case of Nuclear Power. *British Journal of Political Science, 23*(1), 29-50.
Poortinga, W. (2005). The use of multi-level modelling in risk research. A secondary analysis of a study of public perceptions of genetically modified food. *Journal of Risk Research, 8*(7/8), 583-597.
Poortinga, W., Bronstering, K., & Lannon, S. (Early View (Article first published online: 7 APR 2011)). Awareness and Perceptions of the Risks of Exposure to Indoor Radon: A Population-Based Approach to Evaluate a Radon Awareness and Testing Campaign in England and Wales. *Risk Analysis*.
Poortinga, W., Cox, P., & Pidgeon, N. F. (2008). The Perceived Health Risks of Indoor Radon Gas and Overhead Powerlines: A Comparative Multilevel Approach. *Risk Analysis, 28*(1), 235-248.
Potter, W. C. (2010). The npt & the sources of nuclear restraint. *Daedalus, 139*(1), 68-81.
Raudenbush, S. W. (1989). "Centering" predictors in multilevel analysis: Choices and consequences. *Multilevel Modelling Newsletter, 1*(2), 10-12.
Rihoux, B., & Rüdig, W. (2006). Analyzing Greens in power: Setting the agenda. *European Journal of Political Research, 45*(Supplement 1), 1-33.
Rosar, U. (2003). Die Einstellungen der Europäer zum Euro. Ein Anwendungsbeispiel der Mehrebenenanalyse als Instrument komparativer Umfrageforschung. In S. Pickel, G. Pickel, H.-J. Lauth & D. Jahn (Eds.), *Vergleichende politikwissenschaftliche Methoden: neue Entwicklungen und Diskussionen* (pp. 221-245). Wiesbaden: Westdeutscher Verlag.
Rothman, S., & Lichter, S. R. (1987). Elite Ideology and Risk Perception in Nuclear Energy Policy. *The American Political Science Review, 81*(2), 383-404.
Siegrist, M., & Cvetkovich, G. (2000). Perception of Hazards: The Role of Social Trust and Knowledge. *Risk Analysis, 20*(5), 713-720.
Sjöberg, L. (2000). Factors in Risk Perception. *Risk Analysis, 20*(1), 1-12.
Sjöberg, L. (2001). Limits of Knowledge and the Limited Importance of Trust. *Risk Analysis, 21*(1), 189-198.
Slovic, P. (1987). Perception of risk. *Science, 236*, 280-285.
Slovic, P., Flynn, J. H., & Layman, M. (1991). Perceived Risk, Trust, and the Politics of Nuclear Waste. *Science, 254*, 1603-1607.
Snijders, T. A., & Bosker, R. J. (1999). *Multilevel Analysis, An Introduction to Basic and Advanced Multilevel Modeling*. London: Sage.
Snijders, T. A. B. (2005). Power and sample size in multilevel modeling. In B. S. Everitt & D. C. Howell (Eds.), *Encyclopedia of Statistics in Behavioral Science* (Vol. 3, pp. 1570-1573). Chicester: Wiley.
Stagl, R. (1986). Der Einfluss der Distanz bei der Wahrnehmung von Kernkraftwerken in den USA und der Bunderepublik Deutschland. *Vechtaer Arbeiten zur Geographie und Regionalwissenschaft, 2*, 107-120.
Surrey, J., & Huggett, C. (1976). Opposition to nuclear power: A review of international experience. *Energy Policy, 4*(4), 286-307.
Torgler, B., & García-Valiñas, M. A. (2007). The determinants of individuals' attitudes towards preventing environmental damage. *Ecological Economics, 63*(2-3), 536-552.
Valentine, S. V., & Sovacool, B. K. (2010). The socio-political economy of nuclear power development in Japan and South Korea. *Energy Policy, 38*(12), 7971-7979.
van Everdingen, Y. M., & Waarts, E. (2003). The Effect of National Culture on the Adoption of Innovations. *Marketing Letters, 14*(3), 217-232.

Venables, D., Pidgeon, N., Simmons, P., Henwood, K., & Parkhill, K. (2009). Living with Nuclear Power: A Q-Method Study of Local Community Perceptions. *Risk Analysis, 29*(8), 1089-1104.

Viklund, M. J. (2003). Trust and Risk Perception in Western Europe: A Cross-National Study. *Risk Analysis, 23*(4), 727-738.

Whitfield, S. C., Rosa, E. A., Dan, A., & Dietz, T. (2009). The Future of Nuclear Power: Value Orientations and Risk Perceptions. *Risk Analysis, 29*(3), 425-437.

Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy, 35*(5), 2683-2691.

Wynne, B., Waterton, C., & Grove-White, R. (2007). *Public Perceptions and the Nuclear Industry in West Cumbria*. Lancaster: Centre for the Study of Environmental Change, Lancaster University.

Appendix:

Table A I: Variables used in the empirical analysis

Variable	Coding & construction	Source
Dependent variables		
OPINION	25: totally in favor 50: fairly in favor 75: fairly opposed 100: totally opposed to energy production by nuclear power (don't knows were set to the country specific mean)	Special EB 297 v152
BENEFITS	Composite index (arithmetic mean) for the approval of the following three statements about nuclear energy: - nuclear energy diversifies our energy sources, - nuclear energy reduces the dependence on oil - nuclear energy reduces the emissions of greenhouse gases 25: totally agree 50: tend to agree 75: tend to disagree 100: totally disagree	Special EB 297 v154, v155, v156
Level-1		
Sex	1: male 0: female	Special EB 297 v389
Age	Age of respondent	Special EB 297 v390
Household size	Number of household members 1: one member 6: six members 7: seven or more members	Special EB 297 v403
Children	Are there children age 1 to 14 living in household? 1: yes 0: no	Special EB 297 v398, v400
Age at end of education	Age when completed full time education (as a proxy for the educational level; "still studying" were set to 18)	Special EB 297 v387
Single	1: single 0: everything else	Special EB 297 v386
Type of community dummies	rural (1/0) small town (1/0) large town (1/0; reference category)	Special EB 297 v395
Prosperity index	Possession of consumer goods (proxy for economic well-being) Calculation based on the availability of the following goods for the respondent: television + dvd-player + cd-player + pc + internet access + 2*car + 3*house) (range 0-10)	Special EB 297 v430-v437
Left-right self-placement	1: left 10: right (don't knows were set to the country specific mean)	Special EB 297 v383
Distance next NPP (log)	Distance between regions center where the respondent is living and nearest active NPP	Own calculation based on: Special EB 297 v473-v513, http://world-nuclear.org/NuclearDatabase/Default.aspx?id=27232, and Google maps
Age next NPP	Age of the next active NPP (in years)	IAEA Power Reactor Information System (PRIS) http://prisweb.iaea.org/
Self-assessment of knowledge about nuclear waste	1: not at all informed 4: very well informed	Special EB 297 v151

Real knowledge about nuclear waste	Composite index Consisting of 12 knowledge based questions that can be either wrong (0) or right (1) answered. (For example: Is high level radioactive waste produced only in nuclear reactors?) (range: 0-12) Higher values indicate better knowledge of nuclear waste (proxy for nuclear energy in general)	Special EB 297 v157 – v168
Trust in official sources	Composite index trust in information about the way radioactive waste is managed from official sources - trust in government 0/1 - trust in national agencies 0/1 - trust in nuclear industry 0/1 (range: 0-3) Higher values indicate higher trust	Special EB 297 v172, v173, v 178
Trust in alternative sources	Composite index trust in information about the way radioactive waste is managed from alternative sources - trust in NGOs 0/1 - trust in international organizations working on peaceful uses of nuclear technology 0/1 - trust in the media 0/1 (range: 0-3) Higher values indicate higher trust	Special EB 297 v179, v176, v174
Level-2		
Seatshare green	Average seatshare of Green parties in national parliament between 01.01.1997-12.31.2007 (in per cent)	http://dev.parlgov.org/data/
Cabinet green	Average government participation of green parties between 01.01.1997-12.31.2007 (in per cent)	http://dev.parlgov.org/data/
Uncertainty avoidance	Societal tolerance for uncertainty (empirical range: 23-112) higher values indicate weaker tolerance for uncertainty	http://www.geerthofstede.nl/research--vsm/dimension-data-matrix.aspx
Long-term vs. short-term orientation	Societal temporal orientation (empirical range: 24-83) higher values indicate future orientation	http://www.geerthofstede.nl/research--vsm/dimension-data-matrix.aspx
Reactors per population (in Mio.)	Number of reactors in relation to population	http://prisweb.iaea.org/
Press freedom	Degree of free media (empirical range: 9 – 42) lower values indicate more press freedom	http://www.freedomhouse.org/template.cfm?page=393&year=2007
Energy imports per capita	Net imports of primary energy (imports minus exports), in 1000 tons of crude oil per capita	http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=de&pcode=ten00083&plugin=1
PS-Index	Index capturing the interaction between electricity price (P) and the share of nuclear energy (S) P: Price for a kWh electricity for an average household (2500-5000 kWh), all taxes included, in EURO (2007 second half, Italy first half 2008) S: (gross nuclear production self-producers & public producers)/(gross total production self-producers & public producers)	Price: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_pc_204&lang=de Nuclear Share: UN Stats - Energy Yearbook (several issues)